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MANUAL

...OF...

Practical Draughting

For Students in Industrial Schools and Schools of Science, Practical Draughtsmen, Engineers and Artisans

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INTRODUCTION.

The use of this book pre-supposes a knowledge of the elements of geometrical and mechanical drawing, and is intended to be used by those who desire to prepare, in addition to their ordinary work, drawings of artistic excellence. Very much of the work turned out in schools and colleges by students of mechanical, civil and mining engineering is of a character not at all suited to the needs of practical men, because they are not taught how to finish their work properly; instruction of this kind, if given when a class commences their technical work, will go very far toward holding their attention in their studies. It is accepted by nearly all teachers that the time spent at work in the drawing room amply repays itself in after years; and if to the ability to design is added the ability to make accurate and artistic drawings, the education of the engineer is nearly complete.

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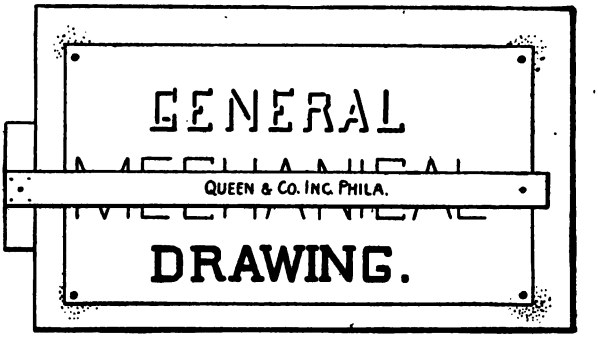


SECTION I.

Instruments, Apparatus and Some Methods.

MECHANICAL DRAWING is the most general kind employed for technical work, and, as such, engages our attention first. As a matter of fact, it is made use of to delineate all forms of apparatus, appliances, machinery, buildings, etc.; the principles of drawing these various objects is, in each case, the same.

The draughtsman's outfit may be either simple or elaborate, and good work may be done with simple tools. It is, of course, necessary that **drawing boards** be on hand, and the simpler in

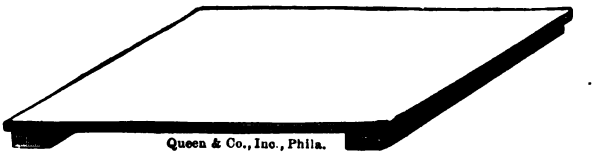


FIG. 1.

construction they are the better. No better board can be had than a plain white pine or poplar surface, properly glued together (if the size of the board demands it) and held plane by means of two strong oak or other hardwood cleats, screwed to the back. It is a mistake to have heavy boards; one of 24 x 30 inches, made of 5/8-inch material, well cleated and cut

and planed as nearly square as possible, will last a very long while. It is absurd to attempt to make all the edges of a board exactly 90° with each other. If *one* edge is cut and planed straight and smooth, drawings of the highest grade and quality can be made. Even this one edge is not an *absolute* necessity.

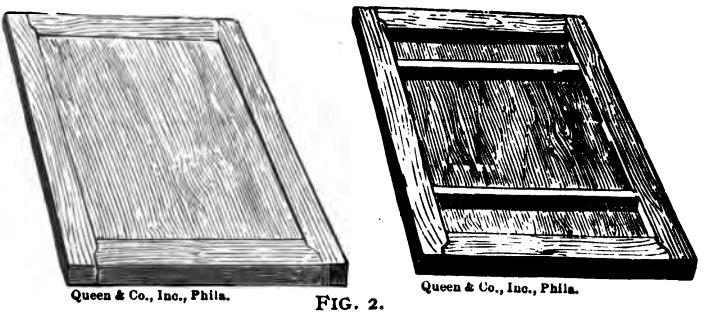


FIG. 2.

The author has frequently made complex mechanical drawings, finished them completely in colors with pen shading in ink, by merely tacking the drawing paper to no other surface or board than the top of an ordinary extension dining table.

Panel Boards are useful for some purposes (particularly those of large size, which are excellent for stretching parchment for illumination or engrossing), but as the frames give

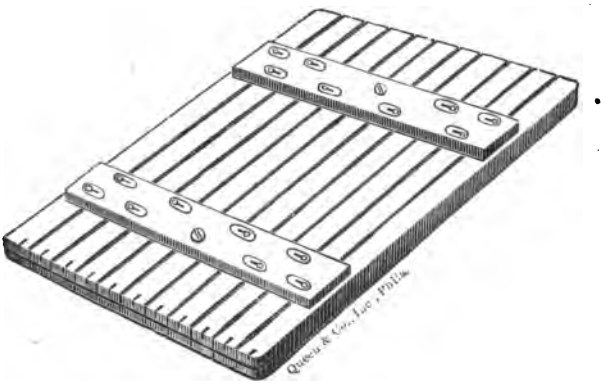


FIG. 3.

out so easily they are not to be recommended for general use. For small drawings, which are to be highly finished in colors, or ink and colors, they answer admirably. Elaborate boards

made up of a large number of strips of pine wood, glued lengthwise, are good. Plain boards, with tongued and grooved edges, are useful, but offer no advantage over the board first mentioned with cleats. The Bergner frame, carrying a parallel moving straight edge and so made that light panels or boards can be inserted, each with its own paper attached, seems very valuable for serial drawings of the same scale. The easel or

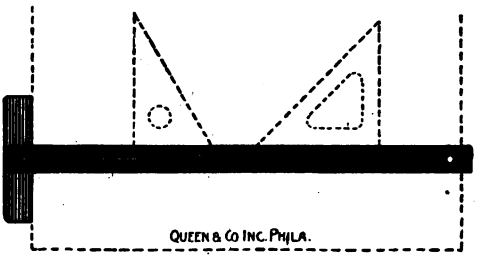


FIG. 4.

drawing-board support of the same inventor is a novel means to hold the board vertical or nearly so, but it is an expensive luxury.

Of Squares, a good, plain T-square is a necessity; and personally, the preference is given those made wholly of wood, for it is found in practice that the lighter in weight the square is, the more readily it can be handled on the board. Squares with a shifting head are extremely useful, and if it is possible to purchase one with a flat swivel-nut do so (Fig. 5). Ordinarily they are made with a milled nut-head projecting about an inch

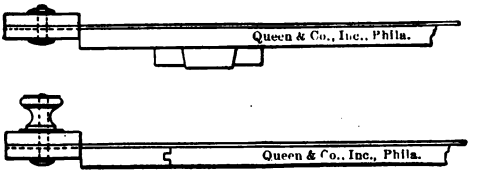


FIG. 5.

above the shifting part, and it is quite inconvenient. If possible, have two squares, large and small, to accommodate the several sized boards in use. Drawings upon very large boards can be made equally well with a four-foot straight edge, without the necessity of having a very long square. For the small boards, the blade of the square can well be of hard rubber. Of recent

years, considerable use has been made of a kind of transparent material for squares, triangles, etc., and it is found to be excellent for the purpose. By its use in T-square blades, the

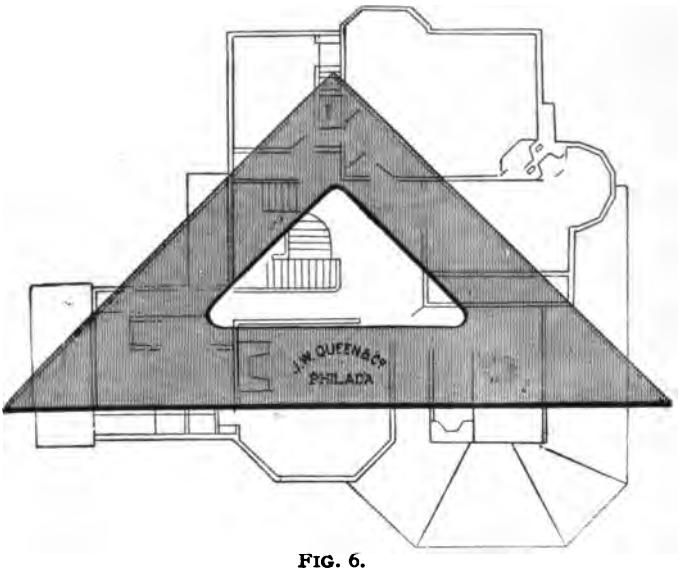


FIG. 6.

draughtsman is enabled to see the work which would otherwise be hidden from view. Always hang the squares up when they are not in use, but not in such a position that direct sunlight will fall upon them, as they will become irreparably

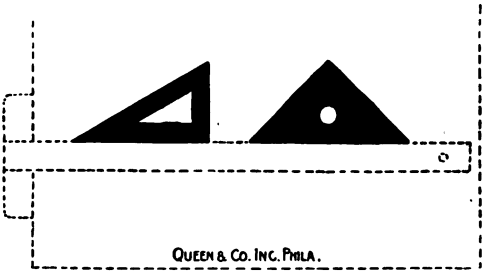


FIG. 7.

warped, but they can with safety be left lying flat upon the drawing; but it is bad policy to stand them up against a wall or leaning against the drawing table.

Triangles can be of wood, hard rubber or celluloid; the latter are the best. Very small triangles, *e. g.*, 2-inch, are a

convenience and useful for many purposes, although some draughtsmen use them only for lettering. Two triangles are necessary—the 45° x 90° x 45° and the 30° x 90° x 60°. They should not be less than 5 inches on the perpendiculars. If two sizes of each can be had, get those of 9 inches also; the larger size is not necessary, however.

FIG. 8.

Irregular Curves (Fig. 8) are very useful, and two will be ample for nearly all kinds of general work, although it is advisable to have several embracing a range of curvatures; they are always useful. They may be of wood, which is cheaper, or of hard rubber or celluloid, this latter substance having properties which commends it above all others. A curve about 7 or 9 inches long has on it almost every curve likely to be called for. A good idea is to purchase a single large curve, say 12 inches, and cut it into two or three pieces, reserving a long piece for special curves. Very long and easy curves are drawn by special pieces; or they can be made equally well by means of a thick ruler, and giving a slight inclination to the pen in drawing.

The Drawing Pen is the most important instrument which now requires attention. A great fault, which is noticed in many cases of drawing instruments, is that this most valuable tool is of such an inconveniently small size as to be of little practical value. Pens come in three sizes, but if choice is permissable, procure the largest; or if two are wanted (and good use can always be made of them), one can be of the middle size, but totally ignore the smallest. Pens are made in several patterns, of which three are the most important: One, where one nib or blade is partly a spring (Fig. 9) and the other fixed; one, with one of the blades hinged (Fig. 10) and the other fixed; and the third and least desirable, with both blades rigidly fixed. The former kind is the best, the hinged blade coming next. They

should be of an excellent quality of steel, and possessed of a considerable degree of hardness. Although a good pen will cost from $1.25 to $1.75, it is well to pay a good price and get an instrument that will last for a long time and be always a

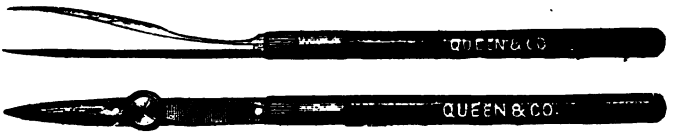


FIG. 9.

pleasure to use. Wood handles are better than ivory or bone, on account of lightness. It frequently happens that pens, as sold, are not properly sharpened, and it is almost an absolute fact that but few draughtsmen really know when a pen is in a proper condition to use. If we examine a pen as it is sold to us, we find that the two nibs or blades are beautifully polished and ground to a small point; if we unscrew them and feel the edge of this point, we will find that it is extremely sharp—so

FIG. 10.

sharp, in fact, that if we were to attempt to draw a heavy line with it we would most likely cut through the paper. It is a mistaken notion to imagine that the use of such a pen is necessary to enable one to draw fine lines. Fine lines—so-called "hair lines"—drawn with the blackest of black Chinese ink, and reduced for photo-engraving to one-twentieth their original breadth, are made by the author's pen—an old one of Swiss manufacture, having a point which appears at first sight to be absolutely blunt.

FIG. 11.

To Sharpen a Pen in order to ensure easy and smooth working, the author turns the little screw up so tight that it will hardly yield another half revolution (Fig. 11), and holds the nibs perpendicular to the surface of an oil stone, wet with water or oil, and, with slight pressure at first, grind the original points squarely off; and then, after loosening the nibs, grind each one down on its

side by holding the instrument at an angle of about 15° or 20° (Fig. 12) with the surface, giving at the same time a slight rocking motion. This side grinding is carried nearly to the finish, when the nibs are cleaned and the final grind given, with the nibs

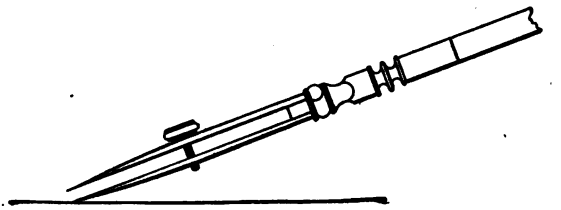


FIG. 12.

brought *nearly* together, with a gentle, rocking motion (Fig. 13). The object is to give to the pen a broad point, ground so as to be as near as possible an arc of a circle, giving only one point of contact to the paper. Pens should be free from oil, and it is important that they be continually wiped free from ink when not in use. This note applies even if the pen is laid down only for an instant, for drawing ink dries very rapidly and very hard. It is well to keep in use a small piece of cotton or linen rag to wipe the pen, and also the wet end of the ink stick, after use. There are several ways of filling a drawing pen with ink—either with a small brush or with a piece of quill, properly cut, or with a writing pen; but experience has shown that it is quicker, cleaner and much neater to dip the nibs of the pen directly in the ink, and wipe off the excess on the outside with the rag just mentioned. The remarks made in regard to the ruling pen refer with equal weight to the compass pens. **Always keep your pens clean.**

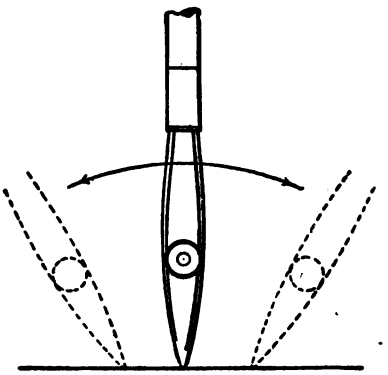


FIG. 13.

It is well to have a pair of dividers with pen, pencil and needle point (Fig. 14). The pencil point can be either of the old style, to accommodate a small piece of lead pencil, or of the patent

variety, so made as to take a short piece of lead. Do not use the kind of point that has a small sleeve to screw over the lead holder, because the thread will eventually wear out and endless

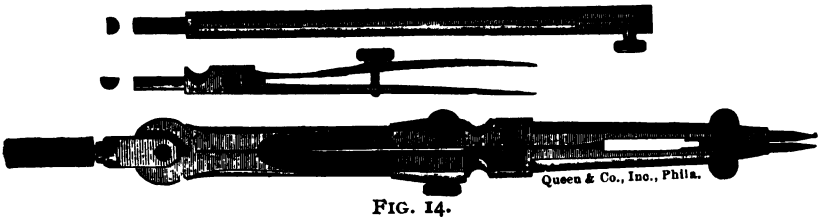


FIG. 14.

trouble will result. A word about sharpening the pencil: A round conical point is not suitable for line drawing, for in use the point wears away and the line becomes broad in consequence. The proper pencil point is flat on the sides, and is

FIG. 15.

made by direct sharpening with a knife, or by filing on a very fine file or emery paper, afterward rubbing smooth on a piece of plain paper. This point is made to resemble a chisel, after which tool it takes its name—the "chisel point."

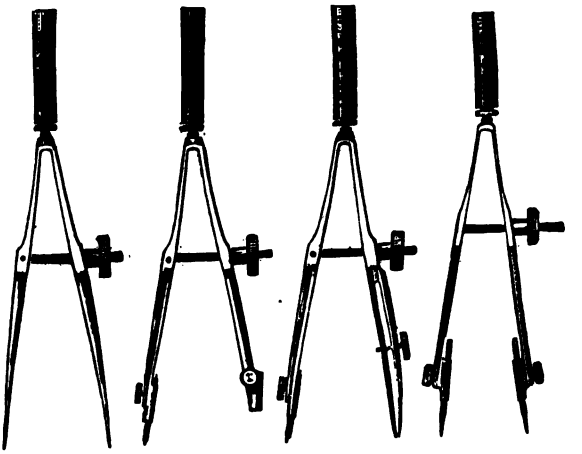


FIG. 16.

A pair of plain or "hair-spring" dividers, 5 inches long, are necessary (Fig. 15), and also a set of 3-inch compasses, spring bow, for small circles (Fig. 16) are ample; also a 3½-inch set

of dividers, with pen and pencil points (Fig. 17). Other instruments, such as proportional dividers, curve pens, etc., are useful, and go far toward facilitating the draughtsman's work.

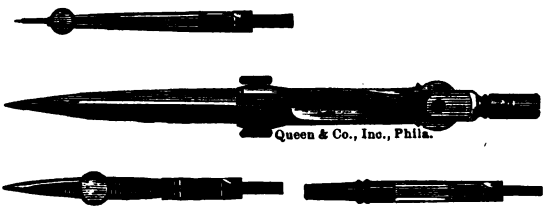


FIG. 17.

The Dotting Pen, for some kinds of work, is useful in saving time, particularly in tracing and in the making of survey maps, etc.; but one who knows how to use the ruling pen, and understands its possibilities, can do any kind of dotting.

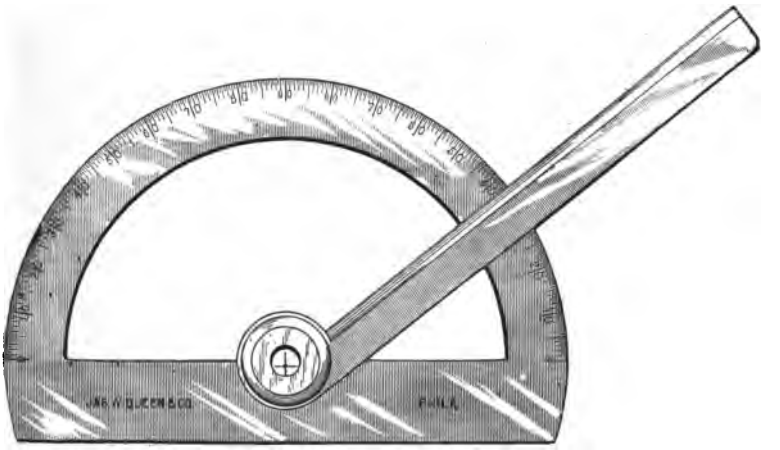


FIG. 18.

Protractors, except for survey work and maps, are seldom used. For ordinary purposes the combination of triangles will give several angles, and the draughtsman can easily construct others. A good protractor is desirable, however, and in purchasing one see that it is about 6 inches in diameter and provided with an arm and vernier.

Scales are valuable. The best kind to have is the triangular boxwood, 12 inches long (Fig. 19). Paper scales for large drawings are extremely useful and remarkably accurate. An advan-

tage they possess over other kinds is that they expand and contract equally with the drawing paper during the various changes of the weather. Paper scales are either engraved or printed; in buying, see that the scale is from a copper plate. These scales are in two sizes, 12 inches and 19 inches long.

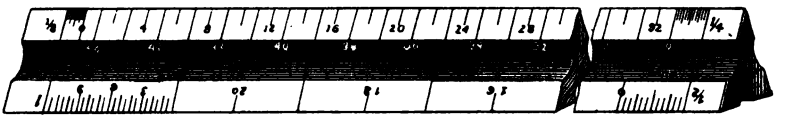


FIG. 19.

Drawing Papers are sold of so many different grades and qualities that it is almost, if not quite, impossible to keep in mind their merits. For general mechanical draughting, of the kind where no special value is to be attached to the drawing after the machine or structure is built, the author employs a thick manilla paper which has a light yellowish tint, smooth surface, and which takes ink and color very well. For drawings of value, a moderate weight "eggshell" paper, with a rough surface, is excellent. This kind of paper is sold under several fanciful names. For small drawings, good use can be made of an unsized white ledger paper. Both the above papers take ink and water colors beautifully. The ledger paper is remarkably available for exhibition drawings in ink alone or in ink and color. It is an excellent paper to work upon. For pure pen-and-ink work, the kind which is intended for reproduction, bristol board or other white, hard, smooth paper is exclusively used. A dead white surface is an absolute necessity for photo-engraving line drawings. Whatman's hand-made drawing papers are much used and answer very well, but they offer no advantage over other kinds and makes when used for mechanical or line work; but if the drawing is in ink-wash or a combination of brush-and-pen work, it is at its best.

The Ink used by the draughtsman is ordinarily of the stick variety, but of recent years there have been brought upon the market a number of liquid inks which have taken a prominent place on the drawing table. The only apparent advantage of liquid inks over stick inks is that rubbing up in a saucer or slab is not necessary. Of the two kinds, leaving out the above considerations, stick inks have the preference if of good qual-

ity. A dollar's worth of stick ink will go very much further than a dollar's worth of liquid ink. For drawings which are much handled, or tracings, the author uses a waterproof ink (Higgins), an excellent article; but the draughtsman can prepare for himself an excellent and durable waterproof ink by rubbing a stick of good Chinese ink in a little water in which a few drops of an aqueous solution of borax and shellac have been added. The author takes a few ounces of water, dissolves in it about half an ounce of borax and as much shellac as it will take up, and this is used for rubbing up the ink. A few

FIG. 20.

drops of an alcoholic solution of camphor imparts to the ink a pleasant odor. It is difficult to select a stick of good ink, but there is a quality sold in sticks 3½ inches long, ¾ inch wide and ⅜ inch thick, with a little gilt lettering (Fig. 20), for $1.50, or half sticks of the same quality for 75 cents. This ink is marked with the usual Chinese characters and an elephant, and when rubbed up with water emits a gentle "oriental odor" resembling musk. A stick when broken is not very glossy on the fracture, and lines drawn heavily are not attacked by common house flies as ordinary Chinese inks are. It works free under the

FIG. 21.

brush, and is excellent for pen work. A good cheap ink for pen work, and one suited for patent office drawings, is the "Lion Head" oval stick (Fig. 21). It rubs easily and yields a very black line, which, however, is glossy. Some draughtsmen do not care for bright lines. This ink is not well adapted for brush work, although it is much used.

Ink Slabs or saucers, the plainer and simpler they are the better. Patent ink containers are useless, being very unhandy to clean. The best slab is made of slate (Fig. 22), about 4½

inches square, 1 inch thick, and covered with a piece of plate glass. In the centre is a shallow cavity about 3½ inches in diameter and ⅜ inch deep, and in the centre of this is a small pit about ½ inch in diameter and ½ inch deep, for the liquid ink to collect. A porcelain slab about 5 inches long and 1¾ inches wide, slanting to a well at the end and provided with a cover, is also good. Another good ink saucer, known as the "Philadelphia" (Fig. 23), divides the honors with the above. It is made of a milk-white glass, and is supplied with the inside grinding surface rough or smooth. A good arrangement also is to have a common ink or color saucer, and rub up the ink on a piece of common school slate about 5 inches long and 1½ inches wide.

FIG. 22.

As lines are drawn in ink to be seen, do not hesitate about rubbing the ink up black. Pale ink is a delusion, and if for tracings is of no value, specially if it is intended to make heliographs or blue prints. To rub ink up properly, use a few drops of water (hardly more than ten), dip the end of the stick

FIG. 23.

of ink frequently in the water while rubbing, and rub with a slight pressure. Here the value of a slate or rough-surfaced saucer will be appreciated. Glazed porcelain does not have the peculiar grinding action on the ink that slate has. If a porcelain saucer is used, the proper degree of blackness can be

found by gently blowing into the ink and noting whether the white saucer can be seen through; if it can, the ink is not thick enough and should be rubbed up longer. With practice, this point can be reached without any difficulty. If the ink is too thick, it will not flow regularly from the pen. Always keep the ink saucer covered to prevent evaporation and keep out dust. With steady use, the saucer can be cleaned out once a week or oftener. After rubbing up ink, make it a habit to wipe off the wet end of the cake of ink with the pen rag to prevent it cracking, as small particles will find their way between the nibs of the pen or hairs of the brush and cause effects on the drawing of a kind difficult to remove.

Fastening the drawing paper to the board is done by two methods. The first is the simplest and most generally employed. It involves the use of **Thumb Tacks**, and in their selection it is well to choose the best. Three kinds are generally sold. The common kind, of various sizes, is a small, round brass head, flat, with a small pin fastened through it by means of a fine screw thread; this pin, after use a short time, becomes dangerous as the head of the pin proper is liable at any time to work through the brass head and puncture the thumb, causing a painful wound. A better kind of tack is made in the same manner, but the steel point has a small shoulder turned on it in such a way as to prevent an accident like the above. This is a good tack, but a little costly. Another tack which is much in use, and besides is cheap and good, is made entirely of one piece of steel wire in the form of a spiral, the point being in the centre as in other tacks. Tack heads ought not to be less than ½ inch in diameter. For small drawings, four tacks, one in each corner, will be sufficient; but if a large sheet is used, or if it is particularly stiff, six or even eight can be used to advantage. If a drawing is likely to take up much time, or if it is to be finished in colors, the best method of attaching the paper to the board is by means of paste. To do this properly requires a little skill and patience; but when the ability to stretch the sheet neatly is acquired the method will almost always be employed, for the satisfaction of working upon a perfectly smooth and taut surface amply repays one for the time and trouble, which is very little. To mount a sheet, say on a 24 x 30-inch board, have the board clean and

cut the sheet to the proper size, and with the aid of a straight piece of wood or blade of a square turn up a 1-inch margin all around the sheet (Fig. 24) and close the corners; with a clean sponge, wet with water but not soaked, dampen the surface of the sheet without wetting the turned-up edge. Now, with a convenient sized brush, apply the paste—starch or flour and water, with a *little* carbonate of soda, boiled in an old tin or stoneware pot—to the outside of the turned-up edge, going around carefully to be sure that no spaces are left without, and then place the sheet properly on the board and as rapidly as possible turn the edge down and bring in close contact by rubbing with a clean handkerchief, or what is preferable, the smooth handle of a pocket knife, taking care as much as possible to draw the paper away from the centre of the board while damp. When it is seen

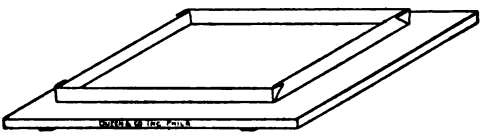


FIG. 24.

that the edge or margin has adhered to the board all around, leave it to dry lying flat on the table or standing up against a wall, but not near a fire. In an hour or so it can be completely dried by holding before a fire or register. It is best, however, to make such mounts in the afternoon and give all night to dry; in the morning a beautiful drawing surface is at hand, suitable for any kind of work. To remove the drawing when finished, cut it out with a knife along the line separating the pasted edge from the wetted surface and soak off the strips which remain adhering to the board.

To mount paper in panel boards always wet it and turn the edge over the back of the panel, insert in the frame, fasten the cleats and stand aside to dry.

Bristol boards or other white cards are always fastened down with thumb tacks, unless a very intricate drawing is to be made requiring considerable time, then it is quite permissable to use a sheet much larger than the drawing and attach to the board with a dab of mucilage on each corner.

The Drawing Table is also a very important adjunct to good work. An excellent support for boards consists of an ordinary square house table and a few pieces of pine wood, planed to the shape of a truncated wedge, and used to raise the back or far edge of the board 5 or 6 inches from the table. No two draughtsmen appear to tilt their boards at the same angle. The author almost always makes use of his writing-table and obtains the best angle by pulling the top drawer out about one

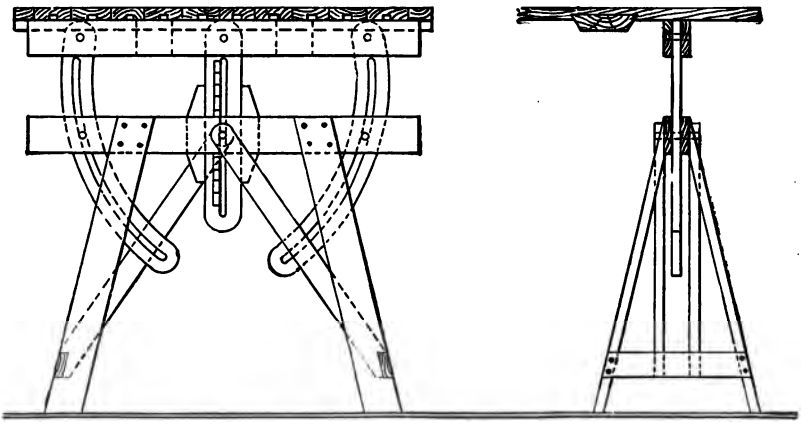
foot and turning the lock, which acts as a catch for the lower edge of the board, and bracing by slipping a book in and under the back end to prevent the board slipping forward. A very good table can be easily constructed from two trestles and bracing together, but this has the disadvantage of having little stability. Perhaps the best table, viewed from an economic

standpoint, and one which has the advantage over all other kinds in having a large roomy top, is one so made that the top folds up so that it can be pushed against the wall. It is the most substantial and cheapest table made. The top is of white pine. The bottom of the table is made of ash, well braced.

Harden's Patent Drawing-Board Trestle is well adapted for general office use, and combines the two important qualities of stability and roominess, besides being so constructed that it is capable of tilting to suit the draughtman's needs. The cost is moderate; single or double, $12.00 to $15.00, respectively.

Harden's Patent Adjustable Drawing-Board Trestle.

Side Elevation. Fig. 1. *End Elevation. Fig. 2.*



For small drawings, especially if they are made continually, such as those to accompany applications for patents, it is well to have a table, the top of which is a drawing board, and to which is tacked the sheet of paper. Such a table top can be easily made to revolve, raise and lower, and tilt at any angle, a very desirable feature for such work, by a few very simple forgings which any blacksmith can make. The small drawing tables with support for the board, and a shelf for tools, colors, etc., are not suited for large mechanical work, besides, with a board on top, they are very top-heavy; but for ordinary offices, where many small drawings are constantly made, they are advantageous. Figure 25 illustrates the general type of table, which has many points to commend.

Proper Light.—As the draughtsman must have light to see to work, it is important that it should be of the right quality. We all want to work at the north windows, for the sun never comes that way, but as it is not always convenient to so locate ourselves, we must modify the light coming in other directions, and for this shades are the best. Two colors are in high repute, light green and light blue. In large cities, particularly in the business sections, many buildings are constructed of marble, granite, or other light colored or white substances, and it is very painful to the eyes to work opposite them, especially is this the case if the sun strikes them. The best form of illumination not always to be had, however, is a sky-light. For night work, preference is given without reserve to the student oil lamp, but it is not always convenient to have one on a slanting table; if a flat-top table is used, and the drawing board inclined, then the lamp is available. It gives a soft, white, steady light. Gas is poor if it is burning at a common burner, but the Welsbach incandescent leaves nothing to to be desired; in drawing under it always use an eye-shade. The electric light has its advocates and its enemies. Never having worked under it the author does not venture an opinion. For color work at night, none exceed the quality of light emitted from a Welsbach.

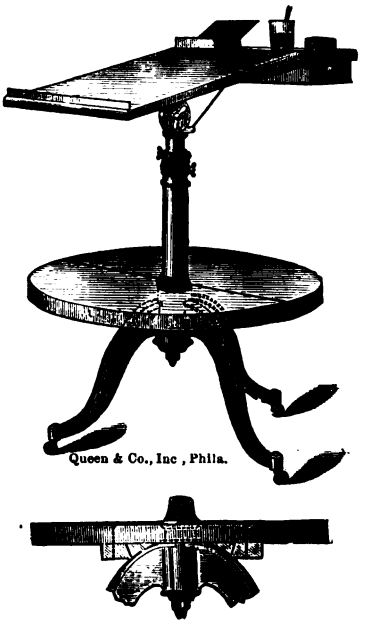


FIG. 25.

It is advisable, when the day's work is done, to cover the drawing board, table, tools as they are left, etc., with a large piece of muslin. This precaution amply repays in reducing the amount of dust which settles during the night, and which is the cause of many soiled and unsightly drawings. A small dust-brush is also a valuable property, also a pair of light shears.

For carrying drawings, as they are always rolled, a yard or a yard and a half of rubber gossamer cloth is very handy, for it prevents the package from getting wet or soiled. For small drawings, pasteboard mailing tubes, or a tin diploma box answer well. Drawings, the size required by the Patent Office (10 x 15 inches), can be carried between two sheets of stiff binders' board; for mailing, they are always rolled.

Pencils and Erasers are necessities, and were left purposely for the last. There are many brands of pencils, and draughtsmen generally have their favorites. Faber's, Dixon's, and Hardtmuth's, of Vienna, are excellent. The author has used all, and finds but little, if any, difference. Personal tastes differ also in the degree of hardness. The author employs for all kinds of general work the HHH grade, but for very fine work uses the 5H or 6H. This point may be decided by each one for himself. Hexagonal pencils are to be preferred to the round, as they are less liable to roll off an inclined board. The remarks made about the "chisel point" leads of the compasses refer also to the drawing pencil.

Erasers are to be had of various kinds. Davidson's velvet and Faber's seem to be the most used. For removing pencil marks from ordinary drawings both are good, but Davidson's has a tendency to remove ink as well. For erasing pencil marks from bristol board either answers, but Faber's does not touch the ink. In regard to this matter, however, much depends upon the ink. High-grade inks being made with very little gum in them are less liable to "smudge" than cheaper varieties; still, cheaper ink is denser and better suited for bristol board work, so, on the whole, it is advised to allow the drawing to become perfectly dry before rubbing out. Ink erasers are used, of course, but to use the words of an old teacher, "it is best not to make any errors with ink." For removing ink lines from bristol board use the steel eraser.

Of course, there are other instruments and appliances which will be found extremely useful in many cases. Every draughtsman procures a set of instruments suited to his own tastes and, in nearly all cases, guided by the requirements of the class of work he has to do.

For the guidance of young draughtsmen, it is recommended that they obtain the advice of some professional draughtsman,

and in purchasing instruments procure such tools as are immediately wanted, and to add others as occasion demands. By this means one will become possessed of a really valuable set; the use and possibilities of each piece will be thoroughly known and appreciated. In purchasing instruments *get the best quality;* they last longer and are cheaper. German silver is the best metal used. Avoid the use of pocket or folding instruments. If it is necessary to carry your instruments, nothing is better than to fold them up in a piece of chamois leather, or have a little satchel or grip, which will also accommodate your triangles, ink, colors, etc., very nicely.

It is not necessary that a mechanical draughtsman should be a mechanical engineer, but it is extremely important that he should have a correct knowledge of "form," and some knowledge of the strength of materials, so that, with a rough sketch in his hands, embodying the ideas of the engineer, he can produce intelligible and accurate drawings for the pattern-maker and the blacksmith. Before commencing the subject of drawing let the remark once made to a class of students be remembered, "*Understand the principles of geometry, the use of instruments,—be a good manipulator, study drawings of all kinds, and imitate only the best.*"

SECTION II.

The Drawing.

This section will not consider what to draw, but, as far as possible, will cover the general methods that are employed in making mechanical drawings, and the remarks herein made will, in most, apply equally to architectural work.

In the first place, if the subject of the drawing admits, always make use of **centre lines.** Their use always insures accuracy, and, besides, in a great many cases, greatly facilitates the work. If the drawing is to be of a piece of machinery which is to stand on a floor or pedestal, suspended from a ceiling, or fastened to a wall, always draw a starting line to indicate such. Take for example a hanger for line shafting. They are always bolted to a girder or ceiling, and in this case, a horizontal line drawn near the top of the board, will at once indicate where the top limit is, and a perpendicular line which is to be the centre line, upon and on either side of which the work will be laid off. In such a drawing, which would be made about half or quarter size, *i.e.*, 6 inches or 3 inches to the foot, the most important point would be the centre of the shaft, where a circle would be drawn, then the centre lines of the bolt holes, properly spaced, would be drawn, and the curve for the frame, which would have to be drawn in with some care; if the hanger is symmetrical only one side is drawn, and when completed the points of the curve are transferred to the other side of the centre line. The box which holds the shafting is then drawn, and the proper dimensions are given to the oil

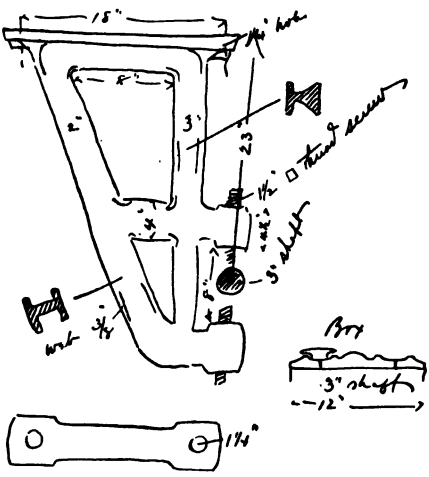


FIG. 26.

cavities. Most hangers have the box so arranged that inequalities in the ceiling will not affect the straightness of the shafting, being provided for by two large screws which hold the box ; they ordinarily have square threads. To render the above plain, the annexed rough sketch is given (Fig. 26)—a fac-simile of one made by the chief engineer of a large works—with a reduced fac-simile of the finished drawing (Fig. 27). This drawing will serve as an index of the general style of work as ordinarily done in large machine shops.

All lines are first drawn in in pencil, and when this part is finished the circles are inked. This ought to be made a positive rule, as it is much easier to join straight lines to circles or curves than the latter to straight lines. After completely inking draw in the centre lines, and then the dimension lines, which ought to be clear and distinct, so that no errors will be made in the machine work ; these latter lines are mostly drawn with red ink, the proper ends being indicated by arrow heads, and by breaking the line for a space of ⅜ inch or less to accommodate the measurement. Use plain figures in marking,

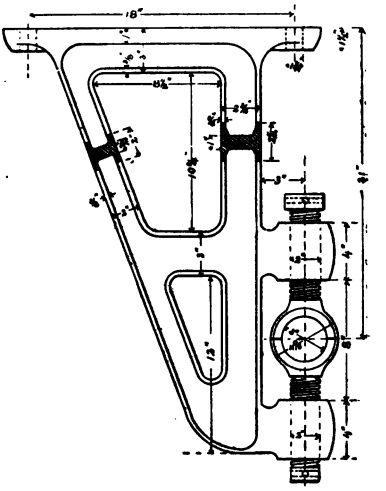


FIG. 27.

and have them of a uniform size throughout the drawing or set of drawings. If the part to be indicated is so small that the figures cannot well be marked on it, it is permissable to indicate them as shown in the annexed figure. After all are in, then commence to erase pencil marks, etc.; and be careful to note any omissions in the inking, for such will occasionally happen. Dimension lines indicating radii are drawn with only one arrow point, the centre of the arc being marked with a small circle, as shown.

Lettering drawings and inserting titles are important, and the *plainest style of letter is invariably the best.* Elaborate shading or scroll work is unsightly, and tends to detract from the

workmanship of the drawing itself. Border lines are seldom employed, except in special cases, and always on patent office drawings, a single line being allowable. Special lines are used for enclosing maps, however.

If it is desired to color the drawing three methods can be used. The first is to apply the color to the drawing before inking, the second is to use water-proof ink, and the third is to wash off the excess of ordinary drawing ink, after the drawing has been rubbed free from pencil marks. This latter method is the best, but can only be done on paper that has been affixed to the board by means of paste. The method is extremely simple, and most beautifully-finished drawings are made with it. The inked drawing is placed in a horizontal position, and with a sponge of clean water in the draughtsman's hand the whole surface of the sheet is gone over somewhat rapidly, and with care to remove with the sponge all the ink that appears to "run" upon the application of water. The sheet is not rubbed, but is rather "mopped up," so that in about five minutes all the ink that will loosen is removed, the board is allowed to dry, and color washes can be applied without fear of any lines blurring. If drawings are made with water-proof ink washing is not necessary, but if a soft finish is desired, particularly if the drawing is for exhibition or office purposes, and to be shaded with ink washes or colored, the method is desirable. For architectural drawings this method is unparalled.

In drawing a steam engine it rarely happens that an elaborate view of the whole is made. As a matter of fact, a side view and general plan is made in order to obtain the floor space required, and to give an idea of the foundations, and also to locate the position of the cylinder, guides, boxes for the crank shaft; beyond this general drawings are not an absolute necessity, but drawings to a larger scale of the several parts, and small drawings of the smaller parts, such as bolts, nuts, eccentrics, crank-shaft, connecting-rod, and detail drawings of the stub ends, the piston and its rod, valves, guides, cross-head, etc.

The principal dimensions of an engine being given, and they generally consist of the diameter and stroke of the cylinder, diameters of the piston and valve rods, diameter of the crank-shaft, size of steam posts, and a few others, accompanied by

general instructions as to how the engine is to be built, the draughtsman is ready to commence. He decides upon a general scale for drawing the parts; for example, an inspection of the rough sketches would show that the future engine will be about seven feet long, not including the half diameter of the fly-wheel, which projects beyond the bed-plate. A convenient outline drawing can be made to a scale of 2 inches to the foot, which will make it 14 inches long; or to a scale of 3 inches, which will give a drawing 21 inches long, and which

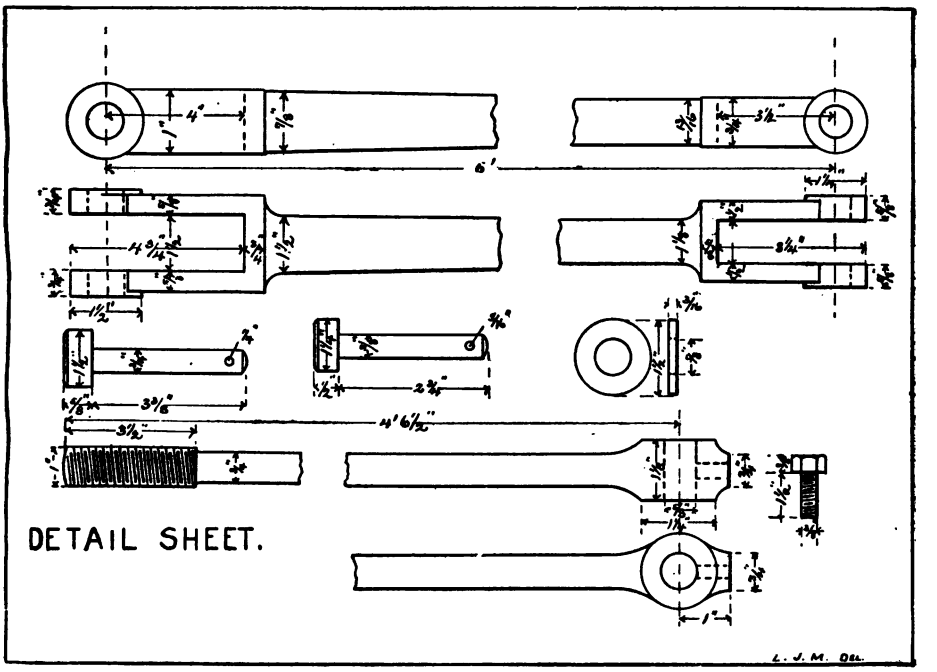


FIG. 28.

for this case is well suited, as much can be drawn on the engine which would otherwise require separate drawings. From this elevation and plan, considerable data is also obtained in regards to the shape of many of the smaller parts. A base line is drawn, and upon it is marked the length of the bed-plate, which may be changed before the drawing is ready for inking; then the depth of the bed-plate is marked and a line drawn through it, then the heighth of the centre of the cylinder above the top of the bed-plate is marked, and a line drawn

through this gives the guide level, and at the same time the line on which the centre of the crank-shaft will be. The diameter of the cylinder is now drawn, the stroke also, allowing for the thickness of the piston and clearance at each end, then the thickness of the cylinder heads, particularly the front one, which carries the stuffing-box and gland; the diameter of the piston rod is drawn, and the stuffing box drawn around it; then the cross head, the guides, and the points indicating the engine on "dead centre," with the length of the connecting rod previously determined; the position of the crank-pin is had, and likewise that of the main bearings. This brief outline gives all that is essential to properly draw an engine. The plan is usually drawn in conjunction with the elevation, and all positions marked on each, such as bolt holes, guides, etc. If the engine is of the horizontal type, then on the plan must be marked the distance from the centre of the cylinder to the valve face. Upon the lines found as above, the draughtsman uses his knowledge of the strength of materials and gradually the completed engine appears. Now, this drawing can hardly be used to build from, so what are called **detail drawings** (Fig. 28) are made from this complete one; separate drawings of the several parts are made, some full-size, some half, some smaller; it is really of no consequence what scale they are drawn to, provided they are convenient to handle, and have all the dimensions accurately marked, for workmen do not, as a general rule, care to handle drawings, or to take measurements from them with a rule. These drawings of the parts are made in groups, so that all parts of which castings are required are made on separate sheets, and those for forgings, on others. These drawings need not be elaborate, *but they must be accurately marked with the exact dimensions.* Detail drawings are sometimes made upon a cheap white paper, pasted to a heavy cardboard, provided with a ¼-inch grommet, to hang up by in the shop, the card being varnished, so that machine or tool grease can be easily removed without injuring the drawing; or they can be made upon manilla paper, and, when finished, carefully traced upon tracing cloth, and this used, being more durable than paper, or preferably, to make blue prints from the tracing, keep the latter intact, and send the former into the shops to work from. If, from any cause, they are lost or

destroyed, duplicate copies can be furnished in half an hour. This reproduction process will be explained further on. A blue print of a tracing of the original plans of the engine is used to erect from, and thus the drawings have done their duty. The knowledge of the engineer, with the skill of the accurate draughtsman, coupled with the perfection of machine tools, have rendered it possible for every part of an engine or machine to fit exactly and to do its proper work without assembling them previously together.

If drawings of a new machine are to be made, and the machine is at all complicated, it is not an unusual practice to make them on several drawing boards at the same time and to the same scale; this method is good, for rarely more than three boards are required, and a better control is had on the dimensions.

The proper preservation of drawings is a matter of some importance when there are many. In such cases it is always the better plan to keep them flat, and in drawers; if they are rolled, they are extremely unhandy to get at for reference. Some large establishments pack away the drawings securely wrapped or bound in suitable covers, using only the tracings for reference, and blue prints to work from.

It is a profound mystery to the author how some workmen manage to get on with their work without the aid of drawings —some not even using a rough sketch—and it is even more mysterious why some machinists, capable men, too, are utterly unable to make use of a drawing when one is given them to work from. In some establishments it is the habit to give verbal instructions to make this or that, and when it is finished it generally happens that there is much time lost in trying to reach the proper result than if it were given to the making of a proper working drawing. Good drawings save over and over again their cost, and, besides, if errors are made in the construction of a machine, the drawing is at hand to decide the responsibility, without trusting to the elastic memory of a foreman or workman.

SECTION III.

The Drawing in Particular.

Mechanical drawings are always made first in pencil, then inked, and sometimes colored. Assuming that everything is in readiness, and that we are provided with the subject in the form of sketches or more or less full instructions, we commence our work as outlined on the previous pages, but in order to make all as complete as possible, pencil work will be discussed first and separately from inking or colors.

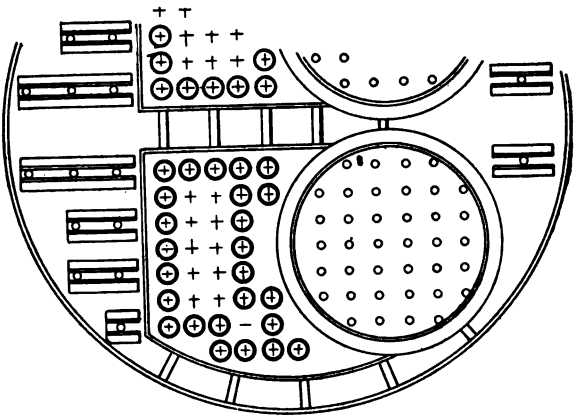


FIG. 29.

All horizontal lines are drawn with the T-square; this is where the value of the straight left-hand edge of the drawing board is apparent, for the square is always manipulated with the left hand, the head being firmly held against the edge of the board by the last two fingers, and down on the board by the thumb and the remaining two fingers, the fingers being on the top edge of the blade, and the thumb on the lower edge. In close parallel line work, the downward movement of the square is regulated by the thumb and middle finger. To be able to have control over the square is one of the very nicest points for the pen-and-ink draughtsman. The square ought never to be used in any other position, and all vertical lines—except those of extreme length—should be drawn with the

perpendicular edge of a triangle, in conjunction with the square. All oblique lines of standard angles, 45°, 30°, 60°, are made with the triangles, an angle of 75° is made by combining a 45° and 30° angle; other lines, if not too oblique, are easily made with the aid of the shifting head of the T-square, and such as are near the vertical can be made with the perpendicular edge of a triangle and the square. Circles are made with the compasses, if very many small circles of the same size are to be made, for instance, in the head of a multitubular boilet (Fig. 29) or condenser, it is quite sufficient to locate the centres by crossed pencil lines, and draw in but a few circles, leaving the remainder to be put in or not when the inking is being done; this method does away with a great many pin holes in the sheet. For such work always use the spring bow-pencil

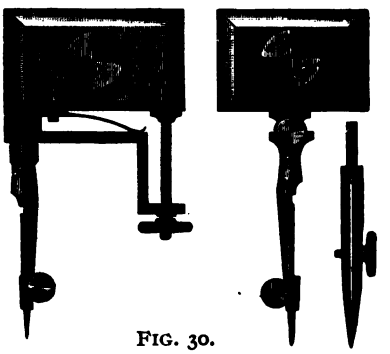


FIG. 30.

for turning corners, small circles, etc.; it is very useful. For larger circles, up to 2 inches radius, the smaller pair of compasses are employed. For very large circles the lengthening-bar is used to carry the pencil point in the large compases, and for the largest circles, say 2 to 3 feet or more in radius, so-called "beam-compasses" are used (Fig. 30). The use of irregular curves is apparent, and it is best to put on the drawing all curves that are not arcs of circles as soon as possible.

In drawing, do not make use of any more lines than are necessary to show where to ink without confusion; this remark applies also to construction lines, which some draughtsmen employ to such an extent as to obscure the real lines of the drawing, and are a very prolific source of errors in the inking.

If many circles are to be drawn from a common centre, it is desirable to have a "horn-centre" (Fig. 31) as a protection to

the point, but if care is exercised the needle point will hardly ever seriously puncture the paper. It is very bad policy to commence inking before the pencil work is finished, as many misdrawn lines will be noticed, particularly if many dotted lines are to be drawn. Always draw the outlines and the larger parts before commencing to fill in with the smaller details. In drawing plans of buildings draw the wall to the proper thickness, and mark the places for door and window openings. If it is a factory building, using machinery which it is desired to show, simply draw the outline, but if it is of a complicated machine merely the actual floor space is sufficient. In some cases, and it is well in all, to draw a line to indicate the power shaft of the machine, and also to show the direction of the main drive in the room. Water, steam, and gas-pipes are also indicated, and to add to the completeness of the draw-

FIG. 31.

ing, stairways, elevators, foundations for engines, boilers, etc.; positions of large pulleys and mill gearing are of importance, also the location of pillars, posts, etc. End views of mill buildings ought to show the position of shafting, main pulleys, and the course of belts. In many cases the position of fire-hose nozzles are shown, and since the introduction of the electric light in mills and factories, the course of the wires is also marked.

Inking the Drawing.—Upon the accuracy and neatness of the pencil drawing much depends as to the ultimate success of the inking. As before remarked, the pens must be in good condition, and the drawing ink of a proper consistency. Circles and curves are drawn in first, followed by the straight lines. All lines which indicate edges to the bottom and right-hand side are drawn somewhat broader than any others. This is a species of shading which adds much to the effectiveness of the drawing, and in giving a proper understanding of the construction.

Always commence at the top when inking and work downwards; straight horizontal lines are drawn with the T square.

If there are many vertical lines to be drawn of any length, it is allowable to use the bottom edge of the board as a guide for the head of the square. Oblique lines are drawn in afterwards, and then the finishing touches. Dimension and centre lines are referred to on page 26.

If sections are drawn, and no color is to be used, it is customary to cross-hatch, that is, to draw a series of closely parallel oblique lines over the sections; for several parts of a piece of machinery in close contact, the section lines must be in opposite directions, and if of different metals or substances, the use of conventional hatches is desirable. One point, often neglected, is not to go over an inked line a second time if possible, and then only when the first is thoroughly dry.

Coloring the Drawing.—Here is where the draughtsman can distinguish himself. There are two general methods in use for coloring mechanical drawings; one involves the use of colored inks used in the pen, and the other, moist or cake colors used with the brush. Either method yields excellent results. The former, however, is the quickest, and besides it is not necessary to treat the drawing as was explained on page 28 for the removal of excess of ink. Nor is it requisite that the sheet be pasted to the board, as it is if wash colors are to be applied. No colored cross-hatching is put on until the outline inking is done, and all pencil marks are removed. For wash colors the method is simple, but requires a little practice, which is obtained without any difficulty. Very few colors are required by the draughtman; for nearly all purposes the following list will answer:—

Prussian Blue.	Yellow Ochre.
Crimson Lake.	Neutral Tint.
Vermilion.	

With these it is possible to make combinations representing almost every substance entering into mechanical construction, such as iron, steel, brass, bronze, leather, rubber, lead, copper, wood, stones, etc. (see page 44). Moist colors are the most suitable, and can be kept best in one of the small japanned tin boxes, which will also hold the brushes, of which about half a dozen will be all that is needed, with two large wash brushes. The draughtsman has choice of two kinds, one in quills, and the other in tin with fixed handles; the latter kind is the most

convenient. In purchasing colors get the full size pans; they are large and will last a long time.

But very little color will be used at a time, and in making up the colors use ordinary white individual butter plates, six are enough, and have always near a tumbler of clean water; a small dropping tube is very useful for transferring the water required from the glass to the plates. In applying color do not use it thick, but rather have it so that it flows easily. It is better to go over a surface twice to obtain the correct shade evenly than to lay it on in one and have it uneven or spotted. Always work from the top down, and do not have any long streaks, but work in horizontal bands, covering, say, ¾ inch each; if this is done rapidly, an even large layer of color will be had. Before applying a second coat allow the first to become quite dry. The above remarks apply to flat tints, and the coloring of sections, for shading elevations, outside views, or drawings other than sections, two methods can be used involving the use of wash colors, and one the use of pen lines over flat tints, which will be mentioned later. Of the two former shades, say cylindrical, can be brought out by blending the same color as is used for the flat tints, only having it much darker at the sides of the part shaded. This is done by laying on a streak of darker shade of the color at the edge, and with a brush dampened with clean water; blend the edge nearest the centre of the cylinder. This is repeated until a properly shaded cylindrical object is obtained. The other method, and one which yields very beautiful results, is done in exactly the same manner, but instead of using the same color over the flat wash, the shading is done with Chinese ink, rubbed thin. Ovoids, spheres, etc. are shaded in exactly the same manner. Shadows are always indicated by flat washes of Chinese ink, care being taken to omit boundary lines; a shadow is never seen with a sharp line defining it.

Pen-and-Ink Shading is of very great value to the draughtsman, and when used with judgment over flat colors, yields results of the utmost beauty and finish. Pen-and-ink work will be treated separately, as it forms a special branch of drawing, although it can be made use of in almost every other branch, and for nearly every kind of illustration or drawing.

SECTION IV.

Tracings and Blue Prints.

This branch of work is ordinarily left in the hands of first year young men in the large machine works, and although it does not require any remarkable amount of skill, yet considerable care is demanded. Before a tracing of a drawing is made, it is necessary that all dimension lines be in their proper place, for if they are not, they will not appear on the tracing, and the final print will be so much defective. Tracings are best made before the finished drawing is removed from the drawing board. **The tracing cloth,** or tracing silk, or linen, by which ever name designated, is fastened, glazed side up, by thumb tacks to the drawing; the glazing is made of a thin solution of statch, and if not very old, takes drawing ink quite readily. If it is old, it acts as if it is greasy, and it is with great difficulty that the ink will adhere, for this reason the author uses waterproof ink, which however, is not always as black as is desired for this purpose; if fresh tracing cloth is at hand, and good Chinese ink rubbed up black as mentioned in another section, it will give tracing lines of great density.

As usual, circles and curved line are drawn in first, then the straight lines. If the tracing is not to blue print, but to be used directly, such parts, if any exist suitable, can be colored. If fresh coloring is desired it is best to apply it upon the dull or unglazed side of the cloth, but if color work in lines is used, it can with safety be put on the glazed side. Wash colors always cause the linen to buckle or crinkle, but after thoroughly drawing all or nearly all defects disappear. Line work is easiest to apply.

Tracing Paper, is employed in exactly the same manner as the linen, but it has no element of durability, and is, besides frequently greasy, owing to the method of manufacture. It is very useful in conjunction with pencil work for transferring. It is also useful for tracings which are made for transmission through the mails owing to its lightness.

Dimension lines are drawn on tracings as they appear on the drawing, generally in red ink, but some draughtsmen draw them

in black ink, but dot the line in such a manner as to make it easily distinguishable from other lines on the finished print.

Blue Prints. The method of indefinitely reproducing plans and drawings by the blue-print process is the most valuable adjunct to any establishment using drawings, and it is remarkable how extensively it has been adopted during the last decade. Aside from the necessity of having good tracings, but very simple and inexpensive apparatus is required.

The Printing Frame (Fig. 32) is the most important, the most expensive part of which is the price of plate glass which must be as large as the largest tracing likely to be printed. The

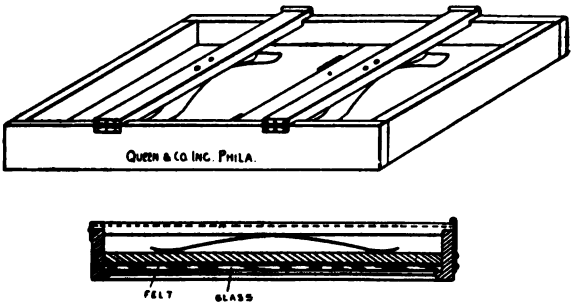


FIG. 32.

frame holds the glass, a few thicknesses of felt or blanketing, and a wooden back in two or more pieces, held together with hinges, and provided with springs on the back, so that it can press against the glass.

To Make a Print, the tracing is laid in the frame, face against the glass, and then a sheet of sensitive paper, coated side against the back of the tracing, the felt cushion put in place, and the whole held tight in place by the back. The frame is now turned up, and inclined so that the semi-light, unobstructed, may fall as directly as possible on the tracing. Upon a clear day in summer, the printing will be over in from 4 to 8 minutes; upon a cloudy day, 15 to 25 or 30 minutes will be required. In Winter, 10 to 15 minutes will suffice on a clear day, but much longer time will be required. The completeness of the exposure can be judged by the peculiar bronzy color assumed by the sensitive sheet, noticed upon partly opening the frame. When the exposure is complete, the sensitive sheet is removed, and sim-

ply washed in water, when the black lines of the tracing will appear white upon a rich blue ground. If the ink lines were drawn with weak ink, the lines on the print would appear pale blue. For washing the prints, a shallow pan is desirable, a very good pan can be made of stiff paper or cardboard well painted and varnished. For very large prints, such as are made in machine works, there is provided an inclined board to which the print is fixed immediately upon its removal from the printing frame, and then washed with a stream from a hose, hung from a line to drain and dry by means of spring clips or other clamps.

The Sensitive Paper can be bought already prepared, either in sheets or in rolls of any length and of excellent quality at low prices; or the suitable paper and the sensitizing solution can be bought separately and the paper prepared; or the solution can be made and applied by one's self. In any case, the paper must be kept in the dark, and if made by the draughtsman, must be also dried in the dark. Any unsized white paper of good quality will answer, but the kind especially made for heliographic work is the best, as it takes the solution without difficulty. The solution can be applied by means of a sponge or soft camel's hair brush, about 3 inches broad. The solution is poured out into a deep dish or other vessel, and the paper, if in sheets, laid on a board slightly sloping, and the coating is commenced, working in horizontal bonds, one below the other until the sheet is covered; if a roll is to be coated it must be kept so that it will not wind upon itself before it is dry. When freshly made, the paper has a good yellow color, but this gradually is changed to a dark green without any appreciable loss in sensitiveness. There is upon the market a kind of prepared muslin to make blue-prints upon exactly as described for paper, and which has the advantage of being very much stronger and better able to stand hard usage, specially in field work. It can be bought in rolls or by the yard, coated or not, as desired. Tracing linen can be made use of in a similar manner with good results.

The Solution. If a solution has to be made use of by the draughtsman, clean out thoroughly, two one-quart ink bottles and in one place 2 ounces of red prussiate of potash (ferricyanide of potassium) and disolve in one quart of warm water; in the other bottle disolve in a like amount of water, 2 ounces of

ammonio-citrate of iron. Equal parts of these solutions, mixed, gives the blue-print solution. The chemicals are not poisonous to handle and can be obtained of any pharmacist. The solutions keep well when not mixed, if they are mixed, they ought to be used within two weeks.

White Lines are easily drawn upon blue prints, by means of a little solution of carbonate of soda (ordinary soda) and used in a writing or drawing pen exactly as ink, when the white line appears, at once cover with a blotter to absorb the excess of soda. The addition of a little glycerine or office mucilage to the soda may make it flow easier and render it less liable to blot. A small bottle of the soda and glycerine can always be kept ready for use, and will be found invaluable.

SECTION V.

Drawing with Pen and Ink.

Pen-and-ink work differs but little from ordinary drawing except that bristol board or other high quality white-surfaced card is used to draw upon, and also that all lines are drawn with the blackest ink and all shades and shadows are represented by means of the pen to the exclusion of every other instrument. As may be surmised from the above, it is quite necessary for one to have good control over the square and pen—and to obtain this, some practice is necessary. A few remarks in regard to the essentials may not be out of place. Nearly all pen-and-ink drawings are intended for reproduction by one of the numerous photo-engraving or photo-lithographing processes; and for this purpose the paper used should have a dead white sur-

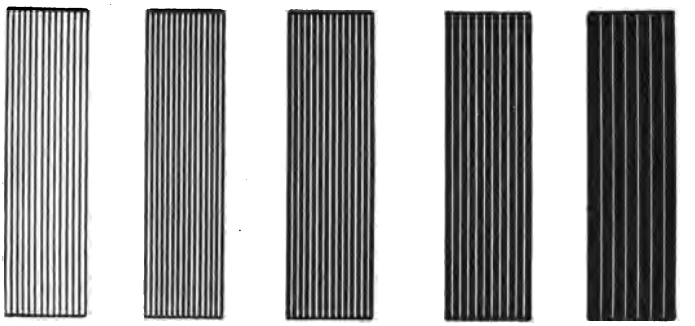


FIG. 33.

face, and to insure success it is necessary that all lines should be drawn in solid and black. By solid is meant smooth edges —edges free from any raggedness. This is most surely obtained with a properly sharpened pen, and by holding it firmly and perpendicular to the surface of the paper. Drawing pens should never be inclined. In using the pen, strive to acquire control over the little screw which opens or closes the nibs, for this is what is principally used in cylindrical shading. However narrow or broad a line may be that you are drawing, have it black. This is a permanent injuction.

To obtain practice, commence by drawing a series of parallel lines about $\frac{1}{20}$ of an inch apart, or less, between two vertical lines 3 inches apart (Fig. 33). To do this properly manipulate the T-square exactly as explained on page 9; after each movement draw a line, and endeavor to keep them equidistant from each other by means of the square only. Commence drawing fine lines; and after several hours incontinuously spent in that practice, go over the same exercise but with broader lines. Keep doing this, and every few inches increase the width of the line until the maximum is obtained with the pen.

For practice and as a test for one's skill, draw parallel lines about $\frac{1}{16}$ of an inch wide and as close together as possible without the ink from one line running into another. Such occasions are often met with in pen drawings where heavy

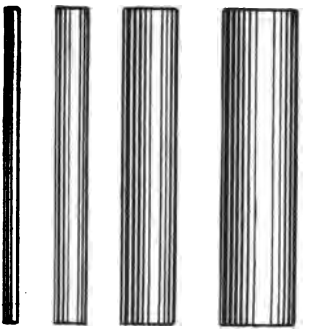


FIG. 36.

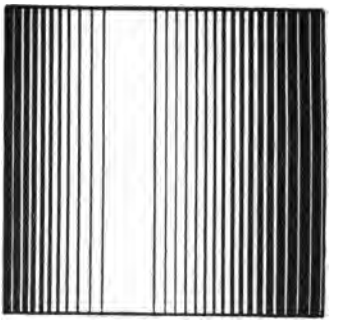


FIG. 37.

shading is wanted. Examples are given of plain shading. Another excellent piece of work for pen practice is to commence with fine lines at the top of the band and, with a gradually increasing width of pen, draw lines to the bottom. This is a good test of one's control over the pen screw.

The next step in acquiring skill in pen drawing is to shade cylinders. For this types are given (Figs. 34 and 35), and it is well to copy them. To shade a $\frac{3}{8}$-inch cylinder, commence with the square and pen at the top and draw downward, with lines of gradually decreasing width; then allow a narrow space, indicating the brightest part, followed by lines of increasing width to the bottom edge, when a broad line is made and finally a narrow one. This last line tends to give the effect of a slight bottom reflection which is always apparent in tubes, etc. The

The lower half of horizontal and the right-hand half of vertical cylinders always have the darkest shade.

For shading spheres or convex surfaces other than cylinders the compass pen is required, and the same precautions are demanded in its use as for the ruling pen; it requires a little practice to exactly gauge how far to move it to draw the next line. All such shading is commenced with the broad lines. A little experience is required to properly join shade lines of two kinds of surfaces; no break or juncture ought to be visible. The whole secret of surface shading, if such it can be called, is merely to have, as far as is within one's control, the distance

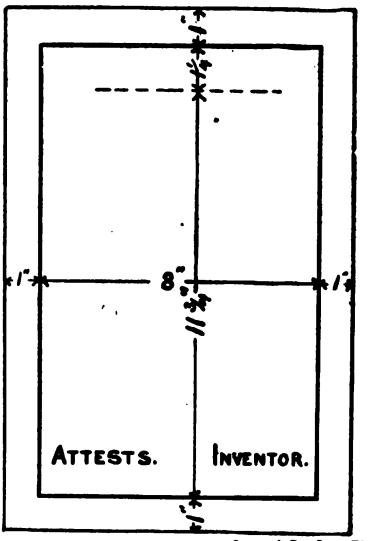


FIG. 36. Queen & Co., Inc., Phila.

from the centre of one line to the centre of the next the same. This applies without any regard to the width of the lines. Some draughtsmen shade with lines of one width, no use being made of the pen screw. Examples are given as types to give an idea how the peculiar effects are obtained.

Patent Office Drawings are always made in ink exclusively, and must be supplied of a certain size (Fig. 36) outside of sheet 10 x 15 inches high and a margin 1 inch wide all around, leaving the actual enclosed space 8 x 13 inches. A space 1¼ inches is left clear at the top for titles, etc., which the draughsman has nothing to do with, it being attended to by the author-

ities. Thus the available space is 8 x 11¾ inches, within which all drawing and signatures must be. In making a patent office drawing, three-ply bristol board is used; and for neatness, which counts for much, it is well to use a sheet a little larger than the size demanded. This allows for trimming down to the proper size, and besides, thumb-tack holes or marks do not appear on the finished drawing. Blank sheets are sold by dealers already marked for "witnesses," "inventor" and "attorney," with the required margin. A sheet 11 x 15 inches can be obtained from card warehouses closely resembling bristol board which is admirable, and allows half an inch to be cut off each side of the drawing.

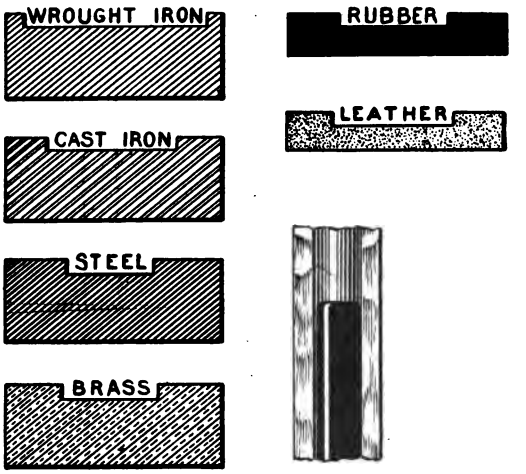


FIG. 37.

The actual drawing is made in pencil from a model, from sketches by the inventor and, in many cases, from a letter of advice or description. This latter is the worst method as it leaves the draughtsman in considerable doubt as to the exact meaning, but it calls for an amount of judgment of a kind rarely demanded by ordinary mechanical draughtsmen. If the invention is of a machine or mechanical contrivance for some special purpose, a perspective view is of great value, and in it all the features that can be shown are put in. This, with the aid of one or two sections or elevations, as may be deemed best, are in most cases quite sufficient. When the pencil drawing is finished, the inking is commenced by drawing all curves and

circles; with care, much of the shading can be done at this time. It is well not to overload a drawing of an invention with shading, but rather to indicate by means of a little the differences between flat and curved surfaces. Much shading is confusing, and besides, does not allow a proper distribution of the reference letters or numerals which must be plainly discernable. In general, the following remarks for this class of work may not be out of place. Keep the sheet as clean as possible, and use only the blackest of black ink. All edges of solids toward the draughtsman, drawn in perspective, are indicated by heavier lines than other edges. Shading is drawn weaker, *i.e.*, with finer lines, as the object recedes from the foreground. Use care in erasing pencil lines so as not to "smudge" ink lines, and never go over an inked line a second time if possible. It is very often possible for the draughtsman to make use of a very fine pointed writing pen, and, with care, much can be done with it, particularly in delineating the fine detail; but it is well to use it as little as possible. The effect of a drawing, except it be of a knitted or similar fabric, is often spoiled by too much free-hand work. It is nearly always used for lettering and for indicating broken sections. Patent office drawings are not made to any scale, but it is a good plan to have the parts shown in a proportion approaching accuracy. Examples of conventionalities, useful in this kind of work, are given (Fig. 37).

When once the ability to draw in ink on hard white paper is acquired, a very great amount of work is possible, such as book illustrations of all kinds, machinery, plans, maps, etc. To be a successful worker in this field it is necessary to be a good perspective draughtsman, and for this much practice is required.

SECTION VI.

Drawing with Flat Colors and Pen and Ink.

Perhaps no more beautiful kind of drawing can be produced than by the combination of ink-shading over flat tints, and if drawings are wanted for exhibition purposes, the draughtsman can choose no better than to adopt this style of representation.

For large drawings, paste the sheet of paper to the board, and when the penciling is completed ink carefully and wash off the excess and allow to dry thoroughly. When dry the flat tints of color can be applied. It is well not to have the colors too weak, nor yet too strong in tone, and as a guide in the choice of colors to use the following list is given, but it can be considerably reduced in number without interfering with any of the shades.

Wrought-iron . . . Prussian blue.
Cast-iron . . . . . Neutral tint, tinged with lake.
Steel. . . . . Pale indigo, tinged with lake.
Chilled-iron . . . . Neutral tint, mottled with Chinese ink.
Brass. . . . . Gamboge.
Copper. . . . . Lake, trace of Chinese ink.
Bronze. . . . . Gamboge, with Roman ochre.
Lead . . . . . Pale indigo, trace of Chinese ink.
Brickwork, plain and section . . . . . Lake.
Brickw'k, elevation, Lake and Venetian red.
Fire-brick . . . . . Gamboge, trace of vermilion.
Stone (average gray) Roman ochre, trace of Chinese ink.
Granite . . . . . Pale indigo and Prussian blue.
Red sandstone . . . Venetian red and Chinese ink.
Slate . . . . . Indigo and lake.
Clay and earth . . . Vandyke brown.
Concrete work . . . Sepia, with sepia markings.
For undressed stone, a gentle mottling with Chinese ink is effective.
Dark woods . . . . Burnt umber.
Light woods . . . . Raw sienna.
Graining and knots can be shown with the aid of a fine brush or writing pen.

After the proper colors have been applied according to the above or similar scheme let the last application dry, and then commence inking in exactly the same manner as for ordinary ink work. As it is difficult to erase ink from over wash colors,

endeavor not to have any blots or misdrawn lines. This style of drawing produces the best results with very much less time than is required for brush shading. In making large exhibition drawings of elevations, etc., do the cylindrical shading before any of the flat shades are drawn. If a section drawing is to be made, cross-hatch lines can be drawn either with Chinese ink or else with a deep shade of the color used for the wash tint. If the colors are put on of a medium strength, neither weak nor deep, and the inking done firmly, a most satisfactory result is obtained, pleasing alike to the draughtsman, the owner, and the spectator. Such drawings are made use of to good advantage by inventors of processes, machinery, etc., being very effective.

Standard Technical Water Colors.—For those who do not wish to mix their own colors the standard colors are to be strongly recommended. They are mixed to conform to the color scheme most generally used by engineers, draughtsmen, etc., and are sold in half and full pans. The colors are:—

Copper,	Lamp black,
Brass,	Machinery green.
Steel,	Vermilion,
Wrought-iron,	Leather,
Cast-iron,	Prussian blue,
Brick,	Carmine,
Stone,	Chinese white.
Wood,	

By using waterproof ink, and being very light in using the pencil, results of the very highest order are obtained upon bristol board, the surface of which is eminently suited for color work; the soft tones of the color washes relieve to a very great extent the sharpness of the pen lines.

This brings to a close all that was intended to be written about technical drawing. As purposely intended, nothing has been said about machinery, buildings, mathematics or geometry, preferring to leave that out of this book, but the authors' desire has been to give the reader plain instructions, and by proper and practical examples, a method, or a touch, whereby he can produce presentable and acceptable drawings to his employer or client. There are many good draughtmen and very many poor ones; the supply of the former has long since been exhausted, although the demand is as vigorous as ever.

SECTION VII.

Drawing on Wood.

The art of drawing upon boxwood, or engravers' blocks, appears to be but little practiced since the more rapid processes of engraving have been introduced, involving the aid of light and chemicals. Notwithstanding this, however, the very finest book illustrations are, with few exceptions, engraved upon carefully and accurately made drawings on wood. The instructions necessary in order to prosecute this class of work are not very extensive, but in order to be at all successful considerable practice is required, or else some very curious errors will be made.

Briefly outlined, a drawing of a piece of machinery upon wood is made in the following manner: First, a correct outline drawing is made in pencil upon paper as it is to appear in print; this is traced upon a piece of strong tracing paper, inverted over a piece of red transfer paper, both being attached by means of a drop of mucilage at the corners to the sides of the block, the face of which has been previously whitened with Chinese white, rubbed on thin. With a very hard pencil, or blunt tracing point (hard pencil is better), the outline of the drawing is transferred to the block, but, of course, in a reversed order. The tracing and red transfer sheets are lifted, and the drawing appears in red; this is done purposely, because the engraver will ignore all lines which appear in colors, he paying attention only to black lines. Within the outlines of the drawing, the draughtsman lays on all the light shades, and little by little fills in, up to the very darkest, all other shades in the various degrees of depth. The application of all shades is done with the brush, and for this purpose several sizes are used. After all shades are in their proper place, and all flat areas properly tinted, the outline is drawn, and always with a pencil (a No. 4 Faber is excellent), with the aid of an irregular curve of small size. A very useful, in fact, necessary tool, is a small 8-inch T square, with steel blade, fixed and shifting brass head; all straight and parallel lines are drawn with it. A hard rubber triangle is of use as a rule for general work on the block.

The colors are peculiar to handle, from the fact that one is working on the end of the grain of the wood, and as a conse-

quence the water soaks in more rapidly than upon paper. For all purposes the colors employed are:

Black	Chinese ink.
Middle tints	Indigo, or Payne's gray.
High lights	Chinese white.

Summing up, the method of drawing upon wood is to have the outline of the picture appearing in light (brick) red lines, and then putting in the shades, commencing with the faintest, and increasing in depth gradually up to the very darkest, and finally touching the high lights and Chinese white. The finish is given with the hard pencil to the outline, which always goes in last. Wherever the engraver meets with water on a drawing, there the block will be cut out completely, and when he encounters black no cutting will be done, as the draughtsman intends it for black on the print; but all intermediate shades are represented by the indigo or gray. Some draughtsmen shade almost entirely with a pencil, but the best results are obtained by the brush method, although the pencil can be used to lend assistance in modifying certain effects. When once an engraver's block is seen ready to be cut, the manner of working will be understood with the above description.

Line drawings are made on blocks, but generally with a pencil; ink can be used for certain kinds of work.

Drawings like those made on wood are drawn on paper or bristol board for practice, and to be able to properly manipulate a block, it is recommended to cut up a few pieces of ⅞ inch wood to various sizes, and glue to the top of each a piece of bristol board, and when dry draw upon it in the manner detailed for boxwood. For practice trace a simple piece of mechanism, and transfer it with red chalk or transfer paper, redrawing it several times until a successful illustration is made. Boxwood is sold in sizes to suit, at so many cents per square inch, and it is always bought by the draughtsman for work he has to do. If several drawings of small size are to be made it is well to do them on one block, as it will be found much more convenient to handle than a small one. The engraver will also do all his work on the same block, and afterwards each cut will be seperated by the saw. The draughtsman should always keep a proof from each block upon which he makes a drawing.

SECTION VIII.

Drawing of Microscopic Objects.

As very few scientific men are good draughtsmen, and few draughtsmen have any very extended knowledge of the natural sciences—a most deplorable fact, the consequence is that drawings made by the former are generally defective from an artistic point of view, and the illustration made by the non-scientific worker is generally lacking in some detail, not noticed by the reader of the paper or book in which the cut appears, but painfully prominent to the author who laments his inability to draw. This condition is difficult to overcome, but it is hoped that a place in the curricula of some of our colleges and scientific schools will be found to provide instruction of a character suitable to enable scientific students to properly delineate their ideas or observations.

Drawing of microscopic objects is done in two ways, one by direct observation and drawing what is seen from memory; the other and most rational method is with the use of a camera lucida attached to the eye-piece of a microscope, and an instrument of extreme value, of which several forms are to be had, the best being Professor Abbé's, made by Queen & Co., Phila. It has a reflector, which, in conjunction with a small perforated mirror, brings the image of the object on the stage of the microscope, and the pencil point on the drawing paper into the field of vision at once. All that is necessary is to draw the outlines directly as seen through the instrument, upon a properly secured piece of drawing paper (bristol board) and finished afterwards by any suitable method, either pen and ink, or transferred to wood as already explained. Drawings of microscopic objects should be so finished as to appear on the paper as if they were seen through a microscope, that is, all parts other than the object in the field of vision enclosed by a a circle, all outside space being left black.

The scale to which microscopic objects are drawn is regulated by the combination of lenses in the microscope. Ordinarily, the paper upon which the drawing is made is raised by means of blocks of wood to the level of the microscope stage, for the reason that that is the generally accepted microscope centre.

The one great fault with many persons attempting this kind of work is that they want to draw everything seen within the field, but the real value of such drawings is that each should represent a special feature of the object, be it animal or vegetable, of course, it is often required that a complete drawing be made in order to show the relationship of parts, one to the other, but most cases call for less. Professor Bastin, in his work on botany states in regards to drawings of microscopic objects and the use of photography as a means of reproduction: "No record of microscopic work is complete without them. By mere verbal description, however accurate, it is scarcely possible to convey to another a clear and vivid idea of a complicated microscopic structure. Nor can photography, useful as it is, take the place of the draughtsman's art. *** But a photograph cannot discriminate. Moreover, a photograph represents clearly only what lies in a single visual plane. That which lies either above or below it is more or less indistinct, confused and confusing. Photography may and will perform an important part in microscopic research; it may oftentimes very materially aid the draughtsman's art, but it can never take the place of it."

The prime use of drawings of microscopic objects is for book illustrations, but very often they are required for use in preparing large diagrams for lecture purposes, which are made from the smaller ones by means of a pantograph, or by enlargement otherwise. For some purposes, drawings of stained objects must be colored exactly to represent the object as it appears under the microscope, in this case it is best to employ bristol board, and draw the outline with a very fine uniting pen in Chinese or waterproof ink, removing the pencil marks, and using the color with small brushes, keeping constant check on the work by reference to the object. The stains used by the microscopist are most commonly:

Logwood	for	Purple.
Carmine	"	Red.
Aniline Green	"	Green.
Aniline Blue	"	Blue.
Bismark Brown	"	Brown.
Picric Acid	"	Yellow.

and a few others, less generally used than the first form mentioned, which are easy to imitate with the ordinary range of water colors listed elsewhere.

Never allow a piece of this work to leave your hands without first satisfying yourself that it is absolutely correct, and that it will answer fully the purpose intended, and if it is being done for a professor or another, submit the work to him before the final touches are given; this act on the draughtman's part does not detract in the least from his ability, but is on the contrary, a compliment to the scientists, who will appreciate it as such, for no one is more interested than he that his illustrations or cuts shall faithfully represent the objects of nature about which he is to lecture or write.

SECTION IX.

Lettering.

The proper selection of a style of alphabet with which to letter a drawing is a matter of some nicety and requires a little judgment. As a rule, plain letters are the most effective, being neater and easier to make than elaborate ones.

The six styles of alphabets shown in connection with this section have been extensively employed by the author, and by a slight modification, also shown, almost any variety can be obtained. For mechanical and other drawings of large size, letters for the titles ought not to be excessively large, nor should they be very small. For small drawings under 24 x 30 inches, letters for the main title ought not to exceed ½ inch in height.

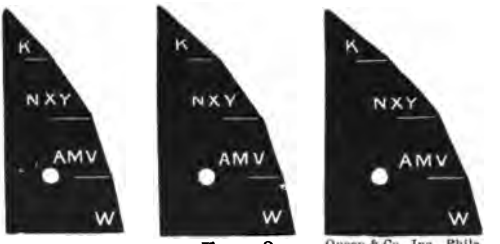


FIG. 38. Queen & Co., Inc., Phila.

There are several methods for drawing letters which meet with favor from various sources, but the one followed by the author is to roughly print the title on a common piece of paper with a pencil, and mark the middle letter or space in each line; then parallel lines are drawn on the sheet to be lettered, of the proper widths for the heights of the letters, when the latter are sketched in with the pencil from the central letter or space to the right, first, then the distance from the central line to the end of the "letter line" is stepped off on the left and then the whole line is completed. All curves and curved letters are drawn in, and finished by filling in the straight lines with the pen. This method, with the aid of lettering triangles (Fig. 38), will be found the quickest, and, besides, one is sure of having one line in its proper place in the centre over the line

below it. If the letters are to be plain, fill in all closed spaces with a brush; if it is desired to shade them, or to partially cross-hatch them, the method will be apparent from the specimens. In inking outlines, after the curves, draw all the horizontal lines, and when the last is dry ink the verticals. A most effective and universally adopted style is the block alphabet, being one capable of many useful and artistic modifications. Scroll work and gorgeous flourishes are decidedly out of place on matter-of-fact drawings, and are not employed in the practice of our best draughtsmen. There are many books upon the market which give alphabets of great beauty, but many of them are made from ordinary type, and some from copper plate engravings, both extremely difficult to imitate. The styles of lettering accompanying contain very much more information than could be written in this section. If they are carefully examined and practiced very little difficulty will be experienced in lettering drawings.

APPENDIX.

MISCELLANEOUS NOTES.

Sizes of Drawing Papers. (Fig. 39.)

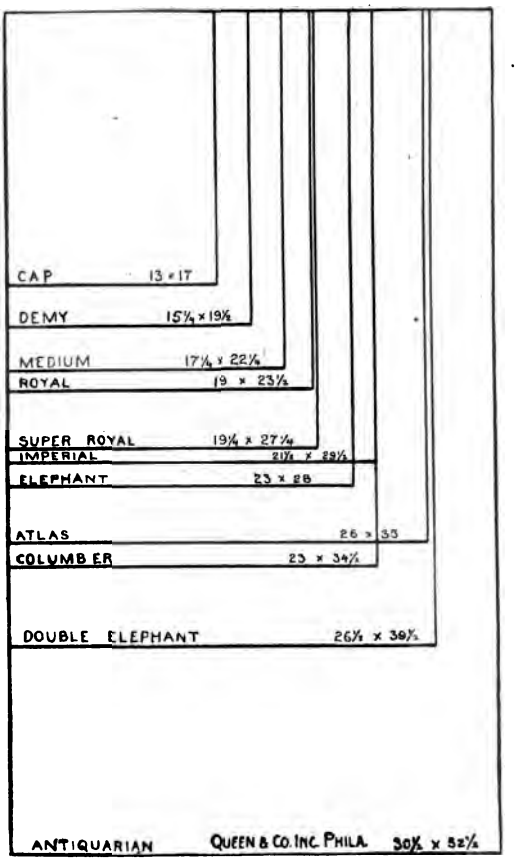


FIG. 39

Cap	13 x 17	inches.
Demy	15¼ x 19½	"
Medium	17¼ x 22¼	"
Royal	19 x 23½	"
Super Royal	19¼ x 27¼	"
Imperial	22½ x 29½	"
Elephant	23 x 28	"
Columbier	23 x 34½	"
Atlas	26 x 33	"
Double elephant	26½ x 39½	"
Antiquarian	30½ x 52½	"

Papers are sold by the sheet, quire, ream, or at pound rates when in quantity. If much is to be bought it is more economical to purchase rolls at pound rates.

Papers in rolls come in various widths. The standards are: 36, 42, 54, 58 and 62 inches, and are usually made up of ten (10) yards.

Tracing Papers.—These papers are in many qualities, and are usually rolls of 11, 22 and 33 yards, and of widths varying from 30 inches to 58 inches. Tracing papers are sold in sheets, sizes varying from 13 x 17 (Cap) to 28 x 40 (Double Elephant).

Tracing Cloth.—This fabric is sold only in rolls, but is also bought by the yard; it is not sold in sheets. Two kinds of three qualities can be had: one with both surfaces glazed, and one with only one surface glazed. Each roll has 24 yards. The widths are 18, 30, 36, 42 and 54 inches.

Blue Print Paper.—This is a convenience for rapid work, and, in view of the time required for coating paper, it is a source of economy if but little blue printing is done. It is sold in sheets (by the quire) in the following sizes:—

16 x 21 inches. 20 x 24 inches.
18 x 22 " 23 x 36 "
27 x 40 inches.

The white paper suitable for making blue prints is sold in rolls, either plain or prepared, of the following widths:—30, 36 and 42 inches, and if bought prepared can be had in rolls of 10 yards; but if plain, in rolls of 50 yards. Several qualities are to be had, varying only in the weight.

Bristol Board.—Two kinds, English and French, can be had, and of three thicknesses, termed respectively "2-sheet," "3-sheet" and "4-sheet." The method of distinguishing the various thicknesses of the sheets is to burn a small strip of each, and the original sheets will be seen to separate.

The sizes sold, singly or by the dozen, are:—

Cap	13 x 17	inches.
Demy	15¼ x 19½	"
Medium	17½ x 22¼	"
Royal	19 x 23½	"
Imperial	21½ x 29½	"

Bristol board can be had in several tints, but these come only in one size—23½ x 19.

Manilla and Detail Papers.—These papers can be had in rolls of 10 yards each, and of the following widths:—36, 42, 54 and 58 inches.

Transfer Paper.—Sold in sheets 10 x 15 inches, by the quire and in several colors, black, white, blue, red, yellow, green, vermilion, light blue, brown, light green, violet and orange.

Water Colors, General.—These come in two forms, as cake, and moist in china pans of two sizes. For water-color work of all varieties the following list will suffice:—

Burnt sienna,	Neutral tint,	Roman ochre,
Raw sienna,	Payne's gray,	Vandyke brown,
Emerald green,	Sepia,	Venetian red,
Gamboge,	Burnt umber,	Vermilion,
Indigo,	Chrome yellow,	Yellow ochre,
Indian red,	Prussian blue,	Crimson lake.

Chinese white is best purchased in small bottles, put up by Dr. Fr. Schoenfeed & Co., Düsseldorf. This white is the best for high lights on wood.

Water Colors, Technical.—The list of technical colors is complete for nearly all purposes, and are useful for rapid coloring. They represent:—

Copper,	Wrought-iron,	Stone,
Brass,	Cast-iron,	Wood,
Steel,	Brick,	Leather.

Liquid Inks, Black.—Higgins' (American). Two kinds, one a general drawing ink, available for brush shading, and a waterproof ink suitable for all kinds of line work. Winsor and Newton (English) ink is for general drawing; it is not waterproof.

Colored Liquid Inks.—But three are of much service to the general draughtsman. They are blue, green and carmine.

Chinese Inks.—But little information can be given to aid in the selection of a good quality of stick ink. An ink highly prized by an artist on account of the excellent tones produced under the brush, would be probably of little service to a pen

artist or draughtsman, and *vice versa*. Hammerton, in his "Graphic Arts" (Boston, 1883), states that a usually good ink can be distinguished by the following properties: "The fracture is black and shiny, of fine texture and thoroughly homogeneous; rubbed with water, no grit is felt, and if diluted with much no sediment is apparent; upon drying, assumes a metallic appearance; flows easily from the pen at a low temperature; when dry on paper, the line will not be disturbed, by being passed over with a brush charged with water. This property is very remarkable, for the same ink dried upon marble or ivory, gives way as soon as it is wetted, which proves that an indelible combination is formed by the ink and paper impregnated with alum."

Chinese ink, in fact, all kinds of stick inks, are made of either lamp black, bone black (ivory black), or the soot from the burning of certain oil; the author has a stick of excellent ink made from the soot of poppy oil, and also a small piece of a stick ink of the soot of oil of sandal wood. The soot is mixed with a binding substance, such as a gum or gelatine, and scented with camphor, musk or "tea," and this latter seems plausible, from the fact that an infusion of tea is astringent, and Hammerton (quoting Mérimée) states that an ink made of a black, mixed with gelatine and an astringent juice renders the ink indelible.

Japanese Ink.—These are generally impervious to water when on a drawing, and this property may be due to the above fact relating to astringent vegetable juices.

Writing Pens Available for Drawings.—Gillott's pens are excellent. The following list includes all useful for general map work, draughting, and lettering:

Gillott's Mapping pens.
" Crow-quill pens, (Lithographic).
" Lithographic pens.
" Nos. 170, 303, and 404.

Brushes, or Hair Pencils.—Two kinds are in general use, large and small; the former being used for applying color to large areas, while the latter are for general detail coloring. These qualities are ordinary met with in two forms, one being in quills, the other in tin with wood handles. The qualities depend upon the kind of hair used. The commonest are made

with "camel hair;" the middle quality with "red sable," the finest with "brown sable." They are sold by numbers, from 1 to 8, the free hair in number 1 being 1/4 inch long, that of number 8 being 7/8 inch.

The wash or large size brushes are thicker, and are either single or double mounted, that is, a brush at one or both ends of the handle.

The size or numbers are,

No. 0.	11/16 inch.	No. 2.	1 3/16 inch.
No. 1.	1 1/16 "	No. 3.	1 3/8 "

Doubles are,

No. 0. . .	11/16 and 11/16 inch.	No. 2. . .	1 1/8 and 1 3/16 inch.
No. 1. . .	3/4 " 1 1/8 "	No. 3. . .	7/8 " 1 3/8 "

Red sable brushes are well suited for general drawing, the brown sable, owing to a peculiar elasticity of the fibre is much prized by water color artists. Brushes ought to be cleaned by agitating in clean water, gently shaken to remove excess of water and form a point. Under no circumstance ought they be passed between the lips.

Paper Scales.—Series A, 1/4, 1/2, 3/4, 1, 1 1/2, 3 inches to the foot. Series B, 3/32, 1/8 3/16, 5/16, 3/8, 7/8 inches to the foot. Series C, 10, 20, 30, 40, 50, 60 parts to the inch.

Standard Sizes of Drawing Boards.—12 x 17 inches, 23 x 31 inches. 16 x 21 inches, 27 x 34 inches. 20 x 28 inches, 28 x 42 inches. 33 x 54 inches.

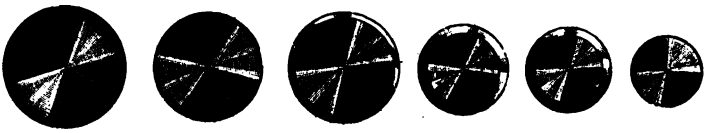


FIG. 43.

Sizes of Thumb Tacks (Fig. 43).—5/16, 3/8, 7/16, 1/2, 9/16, 5/8 inches.

Sizes of T Squares.—Length of Blade. 15, 20, 25, 30, 35, 40, 45, 50, 60, 70 inches.

Sizes of Triangles.—Measured on the isosceles side, 30 x 60 x 90°, 4 to 18 inches, increasing by 1 inch each. 45 x 90 x 45°, from 3 to 14 inches, increasing by 1 inch. Triangles are made of pearwood, cherry, mahogany or walnut, (the latter two lined with ebony or maple) hard rubber, transparent celluloid, and German silver.

PUBLISHERS APPENDIX.

POINTS TO BE REMEMBERED IN SELECTING INSTRUMENTS.

Realizing the difficulty that those residing away from the larger cities (where the stock can be seen and examined) encounter in selecting instruments, Queen & Co. insert this short description of the different classes of instruments and their qualities, hoping that it may throw some needed light on the subject, and make the matter of choosing suitable instruments less difficult.

The finest instruments put on the market were for many years of Swiss manufacture, and they justly deserved the high reputation they had gained for fine workmanship and material, but of late years the American form of instruments, by reason of their superior design, light weight and general excellence, have made rapid strides in public favor, and they now stand at the head, as is evidenced by the number of German and Swiss manufacturers who are now imitating their peculiar form and construction in their own goods, and putting them on the American market. The chief merit of the American form of instrument, apart from its lightness and covenience, is in the perfect joint. This consists of a pivot accurately fitted with a washer between two flat, circular-bearing surfaces, which are clamped together by means of the conical points of two opposing screws carried in a head of German silver metal; these screws are, in turn, held in place by two smaller ones, as shown in cut, and when once the joint is adjusted to suit the requirements of the user, it will have the same touch or feel in all positions.

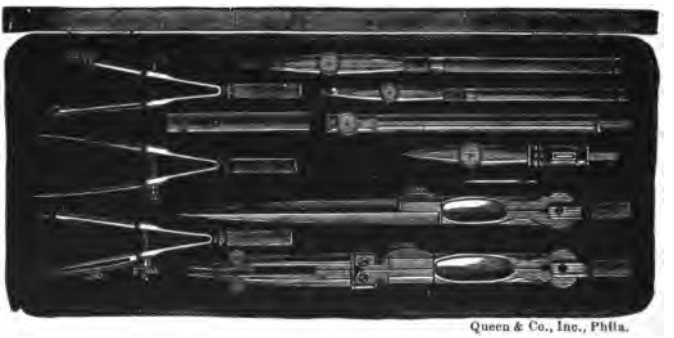
The "Queen" Instruments.

Queen & Co. are now manufacturing these instruments in their own shops, using all the care that almost half a century's experience in manufacturing mathematical instruments would suggest both in selection and quality of the material and in the style of workmanship, and would recommend them to the profession, feeling confident that their superior excellence will much more than repay the slightly increased cost resulting from the greater expense of their manufacture. They stamp their name or initials on all these goods as a warrant of their quality, and if any defects should come to light through usage that can be attributed to a fault either in workmanship or material, they will repair or replace, free or cost, whether purchased direct from themselves or through dealers. The legs of the dividers are provided with knuckle-joints, which enables the points to be kept approximately perpendicular to the paper in making any circles within the capacity of the instruments. The pens are all cut from one piece of steel, without any joints; thus insuring that the points will always match and avoiding the possibility of lost motion. The outer blade is in form of a spring, as shown in the cut, to make them easy of adjustment and to allow

of their being opened to clean, the points being ground and tempered with greatest care so that the ink will flow freely.

The holders for the leads and needle-points are accurately drilled and split to an unusual length (so that clamping-screws will hold the needle-points and lead firmly), and are parallel to the central axis of the instrument. All other details of weight and finish have likewise been carefully considered and perfected.

The spring-bow instruments are made from one piece of steel with German silver handles screwed on, and we would call your especial attention to the nut and washer which, by holding the screw always away from the legs of the dividers when adjusting them, prevent the possibility of stripping the screw. The ruling pen which, of all his instruments, is the most used by the draughtsman, has received their particular attention as to temper and finish, and with the other instruments is fully described in the body of the catalogue.



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The Crown Instruments.

Queen & Co.'s first grade German instruments, made especially for them in Germany, of hard German silver with tempered steel points, are of the best German workmanship, well and carefully finishedand suited to the use of either professional men or advanced students. They are guaranteed as to quality of material, workmanship and durability. These instruments are stamped with a crown.

Queen & Co., Inc., Phila.

The Star Instruments.

The second grade of German instruments, made of fine German silver, with steel points and joints, are superior to other German instruments except those of the grade of the "Crown" brand and are stamped with a star.

The German instruments range in an almost endless variety of grades from the poorest to the good practical working instrument. In catalogueing them Queen & Co. have carefully arranged them in groups according to quality.

The price of different sets in any one group is entirely dependent on the number of pieces in a set, and not on any variation of quality, which is the same throughout each group, and the quality is plainly stated in the descriptions. The cost and quality of the German instruments are dependent on the hardness of the metal, and prices and qualities are graded accordingly. It costs much less to work castings of soft metal than of hard, and for the best grades of these instruments only the hardest metal castings are used. These are coined and hammered to increase hardness and density, while the steel points are very carefully tempered, the tongues of the joints being made of hard steel.

In the commoner grades the joints of the head are either of soft cast German silver like the rest of the instrument, or an iron tongue is inserted to imitate the fine steel joints of the better grades, the points being of iron.

The polishing of an instrument has no relation to the quality, and inferior grades can be given the same outward finish as the best, nor is there any conspicuous difference in the outward appearance of hard or soft German silver, nor in that of soft iron and the hard steel points, and few purchasers have other means of knowing what grade of instruments they are buying than the representation of the dealer, and for that reason it is better to buy only from such houses whose long-established and high reputation will insure their representations being correct.

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The following remarks upon DRAWING PAPERS are intended to aid purchasers in the selection of papers suitable for their various requirements:

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The ACADEMIA PAPERS are of good quality, with a surface well adapted for ordinary school drawing.

The GERMANIA PAPERS are of high grade stock, well made, with a medium surface, suitable for general use.

The CONSTANTIA, in continuous rolls, is a fine white paper, of the best stock, medium in weight, with a slight grain.

The "I. X. L.," a white paper of the finest stock, has a smooth surface on one side, with the reverse slightly roughened. The smooth side is especially suitable for drawings intended to be photographed, the rough for fine office drawings.

The ACME PAPERS, manufactured exclusively for Queen & Co., have been for a number of years steadily, increasing in reputation among the professions in which draughting papers are used, and they have stood every test to which they have been subjected, proving unsurpassed for general work. The color is white, the surface is regularly pebbled, and is equally adapted to general drawing in lines, wash or in water-colors. They are extremely strong, tearing with difficulty, and standing erasing perfectly.

The LEONINE is an extra stout, slightly tinted paper, suitable for shop-drawings requiring much handling.

The PAPIER POURTOUT, of which Queen & Co. take the entire product of the mill manufacturing it, is comparatively new in the American market, but is rapidly gaining a reputation as a desirable addition to the list of good drawing papers, it is white, of pure tone, excellent fibre, and superb erasing quality, with a surface well adapted to general drawing.

Every yard is water-marked "Papier Pourtout," and none is genuine without the water mark.

surface, toughness, hardness and uniformity of finish it is greatly superior to the American manilla papers and to the high priced foreign papers heretofore imported, whilst in price it is but little higher than the ordinary manilla. For workshop use it is unequaled

The "BON ACCORD" PAPER, which Queen & Co. also control, is a detail paper, excellently adapted for general purposes. It is of an agreeable cream buff color, and in all the qualities of

The "DOPPELT" PAPER is a fine detail paper of lighter color and high grade of stock, having a surface of fine grain and standing erasing perfectly. It is peculiarly adapted to fine architectural work.

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